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(54) **FLEXIBLE COLLET ANCHOR ASSEMBLY WITH COMPRESSIVE LOAD TRANSFER FEATURE**

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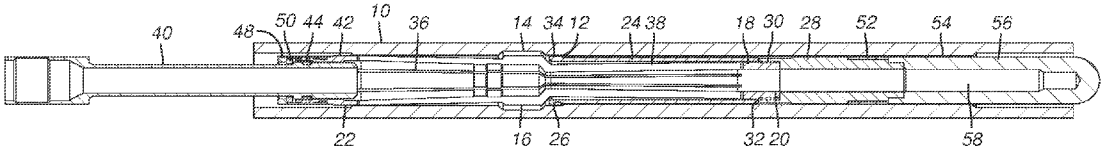
(57) **ABSTRACT**

A collet assembly has a housing and the collets disposed on flexible fingers connected to the housing at their opposed ends. A surrounding landing sleeve stops the assembly so that collets are aligned with a recess in a landing collar that is part of a surrounding tubing string. Once set the landing sleeve transmits compressive loads so that compressive stress essentially bypasses the finger structure supporting the collets. The fingers are initially tapered toward a longitudinal axis so that when internally supported they assume an aligned orientation to the housing axis to allow greater tensile loading and to provide a retraction force when the housing is to be removed after the collet support is removed.



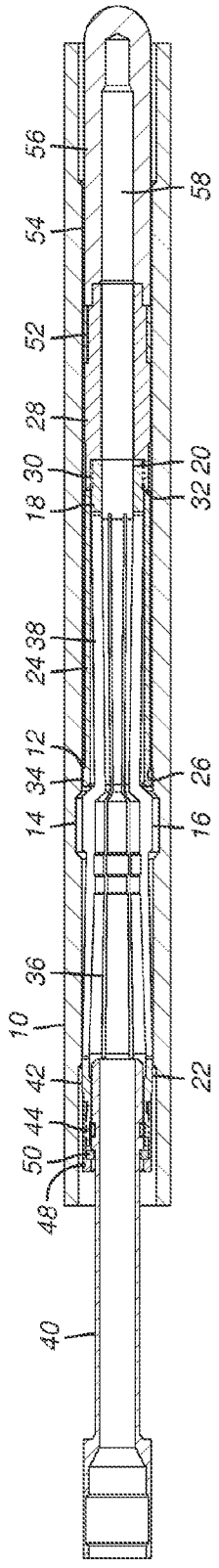


FIG. 1

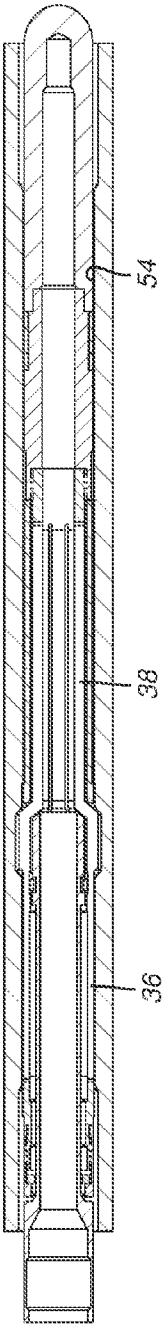


FIG. 2

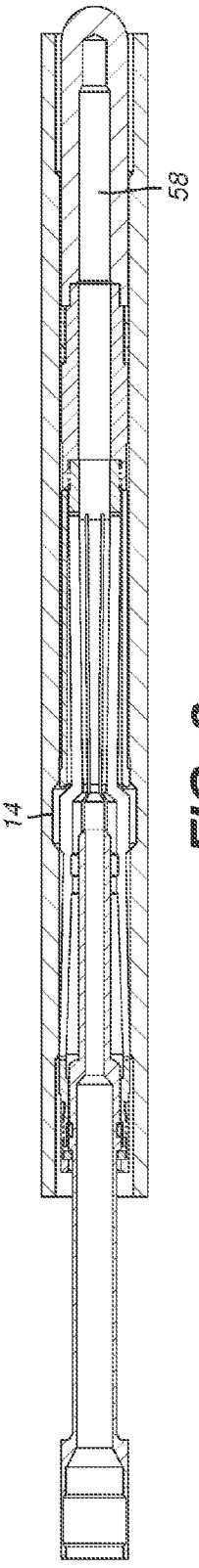


FIG. 3

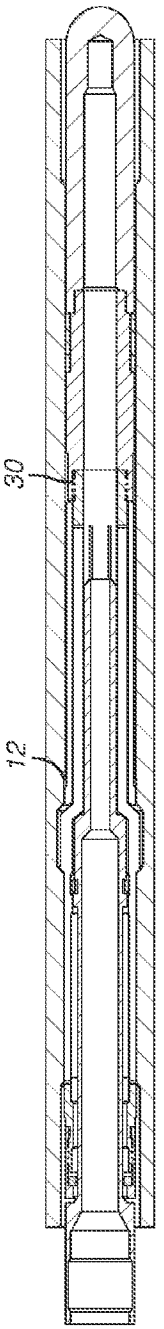


FIG. 4

FLEXIBLE COLLET ANCHOR ASSEMBLY WITH COMPRESSIVE LOAD TRANSFER FEATURE

FIELD OF THE INVENTION

[0001] The field of the invention is collet type anchors for subterranean use and more particularly the collets that are located on flexible fingers for engaging a profile in a tubular string and providing additional features to retain large loads that limit stress to the fingers that support the collet.

BACKGROUND OF THE INVENTION

[0002] Locking devices for support of tools such as plugs in a tubular string have been used in the past. These designs use a recess profile in the string as the location for the engagement of the lock device that supports the tool such as a plug. Typically the string has a no go shoulder so that when the assembly is introduced into the string and hits a travel limit there are an assembly of dogs that are selectively extendable through windows in the housing. These dogs are then extended radially by a sleeve within the tool that has an exterior ramp that engages the dogs. As the sleeve advances the dogs are cammed out and the sleeve has a larger diameter behind the camming ramp that then serves to keep the dogs extended into a profile in a landing collar that is part of the tubular string. The seal of a plug that is installed in this manner lands in a seal bore and is subjected to tensile or compressive stresses depending on the direction of differential pressure. One of the issues with this design in tensile loading with pressure differential coming from above is that the stress is transmitted through the window structure and the thin segments of the housing that defines the region between the windows so that the stress on the housing can get to the dogs that are extended into the recess of the landing nipple in the tubing string. Some examples of this design are U.S. Pat. Nos. 4,510,995 and 4,583,591.

[0003] Another design that can anchor to a surrounding structure is a collet system where the collets are a thick wall segment in the middle of strips made from machined slots in a tubular housing to lend flexibility to the collets for running in and setting when aligned with a groove of a tool downhole. This collet design is generally used in light duty applications such as shifting a sleeve as opposed to supporting an assembly subjected to high stresses from differential pressure such as a plug in a tubular string. These types of tools have generally been run inside other tools to operate an internal component in an existing downhole tool followed by removal when that task is accomplished.

[0004] Yet another type of intelligent collet is described in U.S. Pat. No. 6,464,006 that allows selecting landing or bypassing a support platform to properly position a multi-position crossover tool in a gravel packing context.

[0005] The present invention seeks to use the flexible finger style collet as an anchor device to a tubular string when supporting a tool that will undergo large loads such as 30,000 pounds of force or more. In adapting such as design for high load application the present invention includes features that allow the ability of large compressive loads to essentially bypass the weaker supporting finger structure so that load goes to the collet in the surrounding groove directly through the provision of an external sleeve that doubles in duty as the locating sleeve for the anchor assembly. The fingers are provided with an exterior inward taper so that in the set condition they are axially aligned with the surrounding tubular access rather than being bent outwardly when in the set position. Such an initial orientation also helps to retract the collets when support is removed for retrieval because of their tendency to retract to pull the collet out of the surrounding profile recess when support is removed. These and other features of the present invention will be more apparent to those skilled in the art from a review of the detailed description of the preferred embodiment and the associated drawings while recognizing that the full scope of the invention is to be found in the appended claims.

SUMMARY OF THE INVENTION

[0006] A collet assembly has a housing and the collets disposed on flexible fingers connected to the housing at their opposed ends. A surrounding landing sleeve stops the assembly so that collets are aligned with a recess in a landing collar that is part of a surrounding tubing string. Once set the landing sleeve transmits compressive loads so that compressive stress essentially bypasses the finger structure supporting the collets. The fingers are initially tapered toward a longitudinal axis so that when internally supported they assume an aligned orientation to the housing axis to allow greater tensile loading and to provide a retraction force when the housing is to be removed after the collet support is removed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a section view of the collet assembly in the run in position; and

[0008] FIG. **2** is the view of FIG. **1** with the collet assembly in the set position;

[0009] FIG. **3** is identical to FIG. **1** except for the additional length on the actuator and shown in the run in position; and

[0010] FIG. **4** is the view of FIG. **3** shown in the set position where the additional length of the actuator goes past the collet heads to support the lower end of the fingers if loaded in compression.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] Referring to FIG. **1** a tubular string or a landing collar in a tubular string is represented as **10**. It has a landing shoulder **12** and recess **14** a little above the shoulder **12**. Recess **14** can be a circumferential groove or a series of adjacent groove segments that accept the collet heads **16** as shown in the set position of FIG. **2**. Housing **18** has a lower end **20** and an upper end **22**. The lower end **20** has a smaller outer dimension than the upper end **22** because a landing sleeve **24** with a generally radial surface **26** is disposed over the housing **18** between the collet heads **16** and the lower end **20**. Lower end **20** supports a sleeve **28** at thread **30**. Sleeve **28** defines a support surface **32** for landing sleeve **24**. The upper end **34** of the landing sleeve **24** is designed to contact the collet heads **16** when they are extended into recess **14**. This contact can occur when the collet heads **16** are initially extended into the recess **14**, which lifts sleeve **24** off the shoulder **12**, or it can happen after a differential in the downhole direction puts a tensile load on the fingers **38** which moves the collet heads **16** in the recess **14** to initially achieve the contact with the sleeve **24**.

[0012] The collet heads **16** are supported by upper fingers **36** and lower fingers **38**. Sleeve **24** surrounds lower fingers **38**. On their exterior, the fingers **36** and **38** taper larger going

away from the collet heads **16** and in opposed directions. The same taper is found on the inside of the fingers **36** and **38**. A actuator **40**, when advanced from the FIG. **1** run in position to the set position of FIG. **2** will push fingers **36** radially outwardly until the orientation of the fingers **36** is essentially parallel to the axis of the housing **18** with the collet heads **16** in recess **14**. The actuator **40** stops at travel stop **42** which is a taper at the lower end of the collet heads **16**. The set position is locked by a snap ring **44** carried by actuator **40** that snaps out into groove **46** on fingers **36** in the set position of FIG. **2**. A retainer sleeve **48** holds a retaining ring **50** to secure the actuator **40** and the housing **18** against separation for run in or retrieval.

[0013] Sleeve **28** supports a seal **52** that preferably lands in a polished bore **54** of the landing collar **10**. An end cap **56** closes off the passage **58** to allow the seal to function as a barrier in the string **10**. Those skilled in the art will appreciate that the illustrated anchor can support a variety of downhole tools and the type of tool illustrated is by no means limiting on the application of the disclosed anchor assembly of the present invention.

[0014] Anchors such as the described design can carry 30,000 pounds of load or more and have not been known to be applied to anchors engaging a recess in a tubular string in the past. The finger type collet design has been employed in sleeve shifting or other applications where the tool is deployed to move a part downhole and then removed to the surface. Thus the application of finger type collets in anchor service to a tubular string and more particularly in supporting a plug that will experience large differential pressure and associated stress have not been tried previously. The provision of a sleeve **24** around the fingers **38** that serves not only as a locating sleeve but also under compressive loading as a force transfer mechanism around the fingers **38** and directly to the collet heads **16** is part of what allows the application of the illustrated design as an anchor in a surrounding tubular that is highly stressed in either or both tensile and compressive stresses. Compressive loading passes from the lower end area **20** right into sleeve **24** through support surface **32** of sleeve **28** and right into collet heads **16** through the top end **34** of the landing sleeve **24**. As an alternative, the actuator **40** can be made longer as shown in FIGS. **3** and **4** so that in the set position of FIG. **4** the fingers **38** are narrowly internally guided by the actuator **40** and can be externally guided either with sleeve **24** or, optionally, sleeve **24** can be omitted and the surrounding tubular can also lend support against buckling under compressive loading. In the preferred embodiment of FIGS. **3** and **4** both the sleeve **24** and the longer actuator would be used in tandem. The downside of using both is that the passage through the actuator would get smaller; however, in applications where an end cap **56** is supported by the assembly **10** the diameter of passage **58** is not relevant as there is no need for flow or access through that passage. Leaving out the sleeve **24** will subject the fingers **38** to compressive loading but in some applications where the compressive loads are within acceptable limits and the guiding against the surrounding tubular in the set position of FIG. **4** is close enough, the fingers **38** can be up to transmitting the compressive load without plastic deformation.

[0015] The diverging tapered orientation of the fingers **36** and **38** on run in allows such fingers to be deflected to a parallel or near parallel orientation with the axis of the housing **18** thus providing several advantages over designs that start out parallel and have to be pushed out for engaging collet heads to a surrounding recess. One result is that the tensile stress capability in the fingers **36** is higher because they are not slant oriented when loaded. Prior finger designs pushed the fingers to a slant out orientation for the set position and the present invention provides an initial inward slant toward the collet heads **16** by the fingers **36** so that in the FIG. **2** set position they are closer to axial alignment with the axis of the housing **18**. When the actuator **40** is retracted making the snap ring **44** jump out of groove **46** the potential energy built into the fingers **36** when put in their set position now pushes them back to their original position to help better retract the collet heads **16** from the recess **14**.

[0016] While the presence of sleeve **24** reduces the internal dimension near lower end **20** in the case of a tubular plug this makes no difference as the passage in the string is to be blocked in any event. However, the sleeve **24** can serve as a stress conduit in compression transferring load around the fingers **38** to give the assembly a robust design feature that helps it take high loads so that it can even be used a tubular string anchor having a finger collet design.

[0017] In applications with continuing flow through the anchor the actuator **40** can have a passage through it and the cap **56** replaced by an open tubular to location further away in the string **10**. The inside diameter of the actuator **40** with a passage through it would then not need to be any smaller than the inside diameter formed by the fingers **38** in the set position of FIG. **2**. The sleeve **24** continues to function as previously described.

[0018] The fingers **36** and **38** extend from opposed housing ends and are preferably integral to the collet heads **16** to create the flexible structure of support for the heads in a trapped finger design.

[0019] Those skilled in the art will appreciate that the present invention offers the use of a flexible finger collet assembly to latch into a stationary recess in a tubular string to find support for a downhole tool whether it is a plug as described or some other tool. The fingers are fabricated in a tapering position so that the collet heads are retracted for run in and the fingers assume a more parallel orientation to the surrounding tubular in the set position with the collet heads in the recess. This better enables the fingers **38** to tolerate tensile and compressive loads. The sleeve **24** can be used to bypass fingers **38** when the loading is compressive. Alternatively the actuator **40** can be made longer as shown in FIGS. **3** and **4** so that it provides buckling support to fingers **38** against the surrounding tubular when a compressive load goes through the fingers **38**. As yet another option as shown in FIGS. **3** and **4** the longer actuator **40** can be combined with the sleeve **24** for enhanced protection of the fingers **38** in compressive loading situation. The contact between the collet heads **16** and the upper end **34** of the sleeve **24** can occur on initial extension of the collet heads **16** or can initially occur under loading, whether it is tensile on fingers **38** or compressive on sleeve **24**.

[0020] The above description is illustrative of the preferred embodiment and many modifications may be made by those skilled in the art without departing from the invention whose scope is to be determined from the literal and equivalent scope of the claims below.

We claim:

1. An anchor for securing a tool to a recess adjacent a landing shoulder in a tubular string at a subterranean location comprising:

a housing comprising a plurality of fingers formed between an upper and lower ends thereof that flexibly support collet heads;

an actuator selectively movable with respect to said housing to selectively force said collet heads into the recess; and

a landing sleeve supported by said housing to land on the landing shoulder, said landing sleeve transmitting stress from said housing to said collet heads when said collet heads are supported in the recess.

2. The anchor of claim **1**, wherein:

said landing sleeve overlaps at least some of said fingers.

3. The anchor of claim **2**, wherein:

said landing sleeve is located between said collet heads and said lower end.

4. The anchor of claim **3**, wherein:

said landing sleeve has an upper end in initial contact with said collet heads when said collet heads are supported in the recess or when said housing is under stress with said collet heads supported in the recess.

5. The anchor of claim **1**, wherein:

said fingers taper inwardly from said ends to said collet heads before said actuator is moved.

6. The anchor of claim **5**, wherein:

said fingers are in substantial alignment with an axis of said housing when said actuator moves said collet heads to said recess.

7. The anchor of claim **1**, wherein:

movement of said actuator against said collet heads creates a potential energy force in said fingers, said potential energy force retracts said collet heads from the recess when said actuator is retracted to their original position of tapering inwardly from said ends toward said collet heads.

8. The anchor of claim **1**, wherein:

said housing supports a seal to block a passage through the tubular.

9. The anchor of claim **4**, wherein:

said fingers taper inwardly from said ends to said collet heads before said actuator is moved.

10. The anchor of claim **9**, wherein:

said fingers are in substantial alignment with an axis of said housing when said actuator moves said collet heads to said recess.

11. The anchor of claim **10**, wherein:

movement of said actuator against said collet heads creates a potential energy force in said fingers, said potential energy force retracts said collet heads from the recess when said actuator is retracted to their original position of tapering inwardly from said ends toward said collet heads.

12. The anchor of claim **1**, wherein:

said housing supports loads of at least 30,000 pounds with said collet heads supported in said recess.

13. The anchor of claim **11**, wherein:

said housing supports loads of at least 30,000 pounds with said collet heads supported in said recess.

14. An anchor assembly for securing a tool to a recess adjacent a landing shoulder in a tubular string at a subterranean location comprising:

a landing device comprising a stationary recess and a landing shoulder supported in the subterranean location as an inline part of a tubular string;

a housing comprising a plurality of fingers formed between an upper and lower ends thereof that flexibly support collet heads, said collet heads selectively engageable with said recess;

an actuator selectively movable with respect to said housing to selectively force and retain said collet heads in said recess.

15. The assembly of claim **14**, wherein:

said housing supports loads of at least 30,000 pounds with said collet heads supported in said recess.

16. The assembly of claim **14**, wherein:

a landing sleeve supported by said housing to land on the landing shoulder, said landing sleeve transmitting stress from said housing to said collet heads when said collet heads are supported in the recess.

17. The assembly of claim **16**, wherein:

said landing sleeve overlaps at least some of said fingers.

18. The anchor of claim **17**, wherein:

said landing sleeve is located between said collet heads and said lower end.

19. The anchor of claim **18**, wherein:

said landing sleeve has an upper end in contact with said collet heads when said collet heads are supported in the recess or when said housing is under stress with said collet heads supported in the recess.

20. The anchor of claim **16**, wherein:

said fingers taper inwardly from said ends to said collet heads before said actuator is moved;

said fingers are in substantial alignment with an axis of said housing when said actuator moves said collet heads to said recess.

21. The anchor of claim **14**, wherein:

said fingers taper inwardly from said ends to said collet heads before said actuator is moved;

said fingers are in substantial alignment with an axis of said housing when said actuator moves said collet heads to said recess.

22. The anchor of claim **14**, wherein:

said anchor is configured to axially advance between said collet heads, as said collet heads are extended into said recess, and said lower end of said housing, to lend a guiding support to said fingers between said lower end of said housing and said collet heads when said housing is loaded in compression.

23. The anchor of claim **22**, wherein:

a landing sleeve supported by said housing to land on the landing shoulder, said landing sleeve transmitting stress from said housing to said collet heads when said collet heads are supported in the recess.

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